

Treatability Study Work Plan for SSSTF Stabilization Process (Draft)

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ABSTRACT

This work plan discusses the objectives and methods of conducting treatability studies on a surrogate material with characteristics similar to wastes from nine Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites at the Idaho National Engineering and Environmental Laboratory (INEEL). The wastes are primarily soils containing relatively low levels of radioactivity and Resource Conservation and Recovery Act (RCRA) heavy metals, namely cadmium, chromium, lead, mercury, and silver. To dispose of these waste soils, the heavy metals must be removed or stabilized such that the final treated form does not leach any of the heavy metals above the standards defined by the EPA in 40 CFR 268.

The treatment method proposed in this treatability study is a Portland cement-based chemical fixation system that stabilizes the heavy metals in a nonleachable form. This study will use a surrogate material prepared by using representative site soils spiked with a known quantity of heavy metals. The surrogate will be subjected to an extensive matrix of tests wherein the Portland cement will be supplemented with chemical additives and the stabilization formulation (water and waste loading) adjusted. The treated surrogate will be analyzed via the toxicity characteristic leaching procedure (TCLP), and the paint filter test for free liquid to determine if the treated material would meet disposal criteria. At the conclusion of this treatability study, a baseline treatment recipe will be established – a cement formulation that binds all the heavy metals in a nonleachable product.

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ACRONYMS

AOC	area of contamination
BFS	blast furnace slag
CFS	chemical fixation and stabilization
CRP	Community Relations Plan
DOE/ID	U.S. Department of Energy Idaho Operations Office
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWID	(CERCLA) Comprehensive Waste Inventory Database
EPA	United States Environmental Protection Agency
HWMA	(Idaho) Hazardous Waste Management Act
ICDF	INEEL CERCLA Disposal Facility
IDW	investigative derived waste
IHR	Independent Hazard Review
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LDR	Land Disposal Restriction
OU	Operable Unit
PC	Portland cement
PCB	polychlorinated biphenyl
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SRPA	Snake River Plain Aquifer
SSSTF	Staging, Storage, Sizing, and Treatment Facility
TOS	Task Order Statement of Work

TS	Treatability Study
TSCA	Toxic Substances Control Act
UTS	Universal Treatment Standard
WAC	Waste Acceptance Criteria
WAG	Waste Area Group

Treatability Study Work for SSSTF Stabilization Process Plan (Draft)

1. PROJECT DESCRIPTION

1.1 Introduction

The U.S. Department of Energy Idaho Operations Office (DOE-ID) authorized a remedial design/remedial action (RD/RA) for the Idaho Nuclear Technology and Engineering Center (INTEC) in accordance with the Waste Area Group (WAG) 3, Operable Unit (OU) 3-13 Record of Decision (ROD) (U.S. DOE 1999).

The ROD requires Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remediation wastes generated within the Idaho National Engineering and Environmental Laboratory (INEEL) boundaries to be removed and disposed of onsite in the INEEL CERCLA Disposal Facility (ICDF). The ICDF, which will be located south of INTEC and next to the existing percolation ponds, will be an onsite, engineered facility meeting Resource Conservation and Recovery Act (RCRA) Subtitle C, Idaho Hazardous Waste Management Act (HWMA), and polychlorinated biphenyl (PCB) landfill design and construction requirements. The ICDF will include the necessary subsystems and support facilities to provide a complete waste disposal system.

The major components of the ICDF are the disposal cells, an evaporation pond, and the Staging, Storage, Sizing, and Treatment Facility (SSSTF). The disposal cells, including a buffer zone, will cover approximately 40 acres, with a disposal capacity of about 510,000 yd³. Current projections of INEEL-wide CERCLA waste volumes total about 483,800 yd³. The SSSTF will be designed to provide centralized receiving, inspection, and treatment necessary to stage, store, and treat incoming waste from various INEEL CERCLA remediation sites prior to disposal in the ICDF, or shipment offsite. All SSSTF activities shall take place within the WAG 3 area of contamination (AOC) to allow flexibility in managing the consolidation and remediation of wastes without triggering Land Disposal Restrictions (LDRs) and other RCRA requirements, in accordance with the OU 3-13 ROD. Only low-level, mixed low-level, hazardous, and limited quantities of Toxic Substances Control Act (TSCA) wastes will be treated and/or disposed of at the ICDF. Most of the waste will be contaminated soil, but debris and Investigative Derived Waste (IDW) will also be included in the waste inventory. ICDF leachate, decontamination water, and water from CERCLA well purging, sampling, and well development activities will also be disposed of in the ICDF evaporation pond.

Only INEEL onsite CERCLA wastes meeting the agency-approved Waste Acceptance Criteria (WAC) will be accepted at the ICDF. An important objective of the WAC will be to ensure that hazardous substances disposed in the ICDF will not result in exceeding groundwater quality standards in the underlying groundwater aquifer. Acceptance criteria will include restrictions on contaminant concentrations based on groundwater modeling results with the goal of preventing potential future risk to the Snake River Plain Aquifer (SRPA).

1.2 Background

The wastes that will be processed through the SSSTF are identified in the *Waste Inventory Design Basis* (Preussner 2000). This inventory was derived from the CERCLA Comprehensive Waste Inventory Database (CWID) and the accompanying CWID document text (Doornbos 2000), which contains contaminant identification and concentration information derived from available field sample data. As

presented in the *Waste Inventory Design Basis*, a total of 480,670 yd³ of nonaqueous waste will be processed through the SSSTF, 444,871 yd³ will be disposed directly in the ICDF landfill, and 35,799 yd³ will require treatment before disposal.

The portions of the waste identified for treatment have been designated characteristic (toxic) for heavy metals under RCRA 40 CFR 261. The hazardous metals identified include mercury, lead, chromium, cadmium, and silver. These wastes also contain low levels of beta-gamma emitting radionuclide contaminants and some identified alpha-emitting radionuclides. Table 1 lists the contaminants and concentrations for each of the waste streams requiring treatment.

After analyzing several treatment process alternatives, a chemical fixation and stabilization (CFS) process was chosen to treat wastes within the SSSTF (Raivo 2000). The process will use a cement-based binder that will stabilize the heavy metals and produce a leach resistant (as determined by the TCLP) end product. The information in Table 1 is the basis behind treatability studies that will develop CFS formulations. These formulations will be used to treat the waste to meet the ICDF landfill WAC.^a The treatment process is intended solely for fixation and stabilization of metals and is not considered treatment for radionuclides.

Table 1. Waste inventory targeted for treatment (concentrations are total sample analyses).

WAG	Release Site	Volume (yd ³)	Matrices	Cd (mg/kg)	Cr (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Ag (mg/kg)
5	ARA-12	2,000	Sandy, silty clay with rock pieces ^a	24	460	158	1.4	300
10	Borax-01	11,110	Imported gravel in an area of silty clay soil ^b	120	940	3,340	5.4	2
4	CFA-04	800	Rocky soil with a small percentage of calcine ^c	6	240	40	440	122
3	CPP-92	1,197	Soil ^d					
		4	Metal ^d					
		116	Concrete ^d				20	
		53	Soil/Asphalt/Concrete ^d					
3	CPP-98	30	Soil ^d					
		209	Wood/Nails/Bolts ^d					
		7	Metal ^d					
		4	Undetermined ^d					
3	CPP-99	30	Soil ^d					
		2	Wood/Nails/Bolts ^d					
		11	Metal ^d					
		62	Concrete ^d					
		12	Soil/Asphalt/Concrete ^d					
		9	Undetermined ^d					
1	TSF-07	1	Personal protective equipment					
1	WRRTF-01	20,070	Silty clay ^e		54	2,360	20	
	D&D	72	Rubble (concrete, metal, building materials) ^f					

a. As per C. Bean and the WAG 5 ROD

b. As per C. Bean and the WAG 10 Decision Document Package

c. As per D. Wiggins and the WAG 4 ROD

d. As per C. Bean and the INEEL Integrated Waste Tracking System (IWTS)

e. As per C. Bean and the WAG 1 ROD

f. As per DOE/ID-10803

a. Currently, the ICDF WAC has not been developed and defined. However, it is understood that no free liquids will not be permitted in the landfill.

1.3 Characteristic Waste (D0XX) Determination Process

Characteristic waste is a waste that exhibits the properties of ignitability, corrosivity, reactivity, and/or toxicity as defined in 40 CFR 261. Because the SSSTF/ICDF candidate waste streams are not ignitable, corrosive, or reactive, characteristic waste for the purpose of this study is limited to waste exhibiting toxicity characteristics. In this case, if a TCLP analysis on a representative sample of the waste contains any of the contaminants listed in Table 1 of 40 CFR 261.24 at the concentration equal to or greater than the value listed in that table, then the waste stream is hazardous characteristic waste.

Because TCLP information was not available for all the targeted waste sites, a 20 times (20 X) rule was applied to the "Maximum Concentration of Contaminants for the Toxicity Characteristic" in 40 CFR 261.24. The 20 X rule was used to convert the regulatory TCLP concentrations to a total mass concentration (mg/kg), as shown in Table 2. (This conversion process is outlined in Preussner 2000.) This conversion was performed to compare the total mass concentrations provided in the CWID to the regulatory TCLP contaminant concentrations (Table 2). Those waste streams that have contaminant concentrations greater than the 20 X regulatory concentrations shown in Table 2 were determined to be potentially Hazardous Characteristic waste. These waste streams were compared to the corresponding Universal Treatment Standard (UTS) values (in the manner consistent with 40 CFR 268.49) to determine if the waste streams require treatment. This process, as detailed in Preussner 2000, resulted in the treatment inventory, as shown in Table 1.

1.3.1 Final Determination of Waste Streams

Table 1 lists several waste streams slated for treatment before disposal in the ICDF landfill. However, the only waste site with TCLP results is CFA-04, which consists of 800 yd³ of soil. The TCLP results for this site indicate that chromium, mercury, and silver are leaching above Land Disposal Restriction (LDR) concentrations.

Table 2. 20 X maximum contaminant concentrations for characteristic waste.

EPA HW No.	Contaminant	20 x Regulatory Level (mg/kg)	EPA HW No.	Contaminant	20 x Regulatory Level (mg/kg)
D004	Arsenic	100	D024	m-Cresol	4,000
D005	Barium	2,000	D025	p-Cresol	4,000
D006	Cadmium	20	D026	Cresol-mixed	4,000
D007	Chromium	100	D027	p-Dichlorobenzene	150
D008	Lead	100	D028	1,2-Dichloroethane	10
D009	Mercury	4	D029	1,1-Dichlorethylene	14
D010	Selenium	20	D030	2,4-Dinitrotoluene	2.6
D011	Silver	100	D031	Heptachlor	.16
D012	Endrin	.4	D032	Hexachlorobenzene	2.6
D013	BHC	8	D033	Hexachlorobutadiene	10
D014	Methoxychlor	200	D034	Hexachloroethane	60
D015	Toxaphene	10	D035	Methyl ethyl ketone	4,000
D016	2,4-D	200	D036	Nitrobenzene	40
D017	2,4,5-TP	20	D037	Pentachlorophenol	2,000
D018	Benzene	10	D038	Pyridine	100
D019	Carbon tetrachloride	10	D039	Tetrachloroethylene	14
D020	Chlorodane	.3	D040	Trichloroethylene	10
D021	Chlorobenzene	2,000	D041	2,4,5-Trichlorophenol	8,000
D022	Chloroform	120	D042	2,4,6-Trichlorophenol	40
D023	O-Cresol	4,000	D043	Vinyl chloride	4

Three sites within the WAG 3 area of contamination (AOC) triggered placement (CPP-92^b, CPP-98^c and CPP-99^d) and were slated for treatment. CPP-92 data failed the 20 X rule, but no data exists for the remaining other two sites. Therefore, a TCLP analysis is necessary to determine if these wastes require treatment. Since no data exists to support direct disposal or treatment, they were conservatively identified for treatment until additional information becomes available. In addition, seven other sites located in the WAG 3 AOC (CPP-14, CPP-67, CPP-44, CPP-35, CPP36/91 and CPP-93) failed the 20 X rule, but were targeted for disposal without further characterization because LDRs do not apply for waste within the WAG 3 AOC.^e

In addition to the sites mentioned above, three sites outside the AOC were slated for treatment because of failure of the 20 X rule. These sites, BORAX-1, ARA-12, and WRRTF-01, have been identified for treatment until more data becomes available or TCLP tests have been performed.

Finally, two sites that are not in the database but may require treatment are TSF-07 and decontamination and decommissioning (D&D) waste. TSF-07 comprises 1.3 yd³ of personnel protective equipment (PPE) waste that has been slated for potential treatment and D&D consists of mixed low-level waste (55.8 yd³) and hazardous waste (16 yd³). These streams are not in the CWID, but concentrations stated in the CWID document indicate these wastes may require treatment for characteristic constituents.

1.3.2 Waste Site Sampling

As mentioned in Section 1.3.1, only one waste site identified in the CWID has TCLP data supporting stabilization. This site, CFA-04, consists of 800 yd³ of contaminated soil and occupies only 2% of the volume slated for stabilization. The additional 98% of the stabilization volume is comprised of eight waste streams (ARA-12, Borax-01, CPP-92, CPP-98, CPP-99, WRRTF-01, D&D, and TSF-07) that do not have direct evidence in support of treatment (or direct disposal).

The presumed need for treatment of these nine waste streams is based entirely on the results from the 20 X rule. The 20 X rule provides a red flag for any waste site that might not pass a TCLP for characteristic wastes. It is unlikely that a waste stream would pass the 20 X rule and fail a TCLP. On the other hand, it is probable that a waste stream could fail the 20 X rule and still pass a TCLP. If a waste stream passed a TCLP, treatment (CFS) would not be required.

1.4 Treatability Study Approach

A Portland cement-based media will be used to treat and stabilize the waste. This treatability study will use surrogate waste composed of representative soils spiked with leachable forms of heavy metals. A "worst-case" surrogate material will be prepared. The heavy metal content for each particular metal in the surrogate will be based on twice the maximum expected heavy metal level among the targeted waste sites. For example, the CFA-04 site has the highest expected mercury level at 440 mg/kg; therefore, the surrogate will be spiked to twice this level with leachable mercury. The highest expected cadmium content is 120 mg/kg from the BORAX site; thus, the surrogate will have a cadmium level of 240 mg/kg.

b. CPP-92 consists of 648 soil boxes generated from a variety of INTEC activities.

c. CPP-98 consists of 118 boxes of contaminated wooden shoring.

d. CPP-99 consists of 59 boxes of Tank Farm upgrade low level radioactive soil.

e. As stated in the WAG 3 OU 3-13 ROD, "An AOC is an area of contiguous surface contamination that can be used for the consolidation of remediation wastes without triggering Land Disposal Restrictions and other Resource Conservation and Recovery Act requirements."

The concentrations of the other heavy metals (chromium, lead, and silver) will be determined in a similar manner. The purpose of using the surrogate is to establish a baseline treatment recipe, which will be used as a starting recipe for studies on actual wastes. Performance of the recipe on the surrogate will be based upon TCLP testing, the paint filter test, and other testing as necessary to meet the ICDF WAC. Ideally, the recipe should provide a dry, nonslab-like end product similar in physical character to the original soil. Cure time will not be explicitly examined as a process parameter in these studies as the full-scale design will be based on a relatively short cure time of 24 hours.

1.5 Waste Stream Treatment Verification

This Treatability Study Work Plan establishes the procedure for stabilizing the surrogate waste stream, which represents the bounding condition. Individual waste site RD/RA Work Plans proposing soil disposition at the ICDF will require characterization and profiling of the waste materials. If characterization results indicate the waste may be potentially hazardous, a TCLP analysis will be conducted to determine whether the waste requires stabilization prior to disposal in the ICDF. If stabilization is necessary, the responsible waste site RA manager will provide the SSSTF with a waste sample. Stabilization tests will be conducted by the SSSTF on the sample to further refine the bounding stabilization formula. Performance criteria for the treated waste would include TCLP testing, the paint filter test, the workability of the mix, and any additional testing that may be required as identified in the ICDF WAC.

2. TREATMENT TECHNOLOGY DESCRIPTION

2.1 Trade Study

This section discusses similar sites that have soils contaminated with heavy metals and the technology used to remediate them. Treatability studies performed onsite at the INEEL, other studies, and stabilization demonstrations are also included. Completion of this trade study indicates that cement-based stabilization of metal contaminated soils is an appropriate method for consideration in stabilizing INEEL contaminated soils.

2.1.1 CERCLA Remediation Sites Utilizing Stabilization

Based on conversations with Environmental Protection Agency (EPA) regional project managers, information was obtained on several CERCLA remediation sites where stabilization and solidification of metal contaminated soils was conducted. In virtually all of these sites, cement-based processes were used. Several are discussed below.

Sapp Battery CERCLA Remediation Site:

Lead and chrome were the primary contaminants of concern at this site. Remediation included ex-situ remediation of 100,000 yd³ of soil and stabilization with 7–8% Portland cement, and a proprietary “nectite” (phosphate) agent. Treatability studies performed in support of this remediation showed that much more cement was required if the nectite agent were not used. The process used to combine the soil and stabilization agents was a continuous pug mill. One issue that was considered for this site was that some recipes, which satisfied TCLP tests, failed SPLP tests (another measure of long-term stabilization performance).^f

Continental Steel Corporation OU-02, CERCLA Remediation Site:

Lead, cadmium, chromium, PCBs, and VOCs were primary contaminants of concern in lagoon soils at this site. A Treatability Study was performed by a remediation contractor and may be available through the Freedom of Information Act. Stabilization formulas were based on Portland cement.^g

Schuykill Metal, CERCLA Remediation Site:

Chromium, antimony, cadmium, and lead were the RCRA metals of concern for the contaminated soils remediated at this site. Soil was stabilized with 15% Portland cement and amendments, including phosphates to complex lead. A treatability study was performed by Entech and resulted in a “low tech” mixing process.^h

Normandy Park Apartment, CERCLA Remediation Site:

f. Sapp Battery, Personal Communications with: Contacts: EPA-David Lloyd (404-562-9216), Randal Chaffins (404-562-8929).

g. Continental Steel Corporation OU-02, Personal Communications with: Contacts: Mat Mankowski EPA(312-886-1842), Pat Likins State of Indiana IDEM (317-234-0357).

h. Schuykill Metal, Personal Communications with: EPA Contact Galo Jackson (404-562-8937).

This site, which is located on an old battery-recycling site, is owned by Gulf Coast Recycling. The primary contaminate of concern is lead. Surficial soil was excavated and replaced with clean soil. Remediation of the contaminated soil was performed by cement-based ex-situ stabilization with ultimate disposal in a landfill.ⁱ

Cedar Town Industries, CERCLA Remediation Site:

This site is an old smelter site with soil contamination of Cd, Pb, As, Be, and Sb. The site was remediated with Portland cement as the only stabilization agent. The contaminated soil was excavated, combined with cement in a pug mill and placed back in the previously excavated area.^j

Palmerton Zinc, CERCLA Remediation Site:

Stabilization with flyash, lime, and potash of cadmium and lead contaminated soil. Superfund Site. Found in EPA (1997).

Gould, CERCLA Remediation Site:

Oregon, Stabilization of lead contaminated soil. Found in EPA (1997).

2.1.2 INEEL Treatability Studies

Several RCRA treatability studies on metal contaminated soils have been conducted at the INEEL. Three of those studies are briefly described below.

An INEL RCRA Treatability Study was performed in 1992 on Mercury-contaminated soil/sludge. The primary metal contaminant was mercury and cadmium, with cesium-137 as the primary radionuclide contaminant. The best results in this study were achieved using sulfur polymer cement (SPM) at a waste loading of 33%. Tests were not performed with Portland cement. At this waste loading, the TCLP was reduced on stabilization from 238ppm to 85ppm. The high clay content (60-80%) in this waste stream may have contributed to difficulty in significantly reducing the TCLP value. For more information on this study, see Gering (1993).

An INEL RCRA Treatability Study was performed in 1993 on Pb and Cd contaminated soil. A lead concentration of the untreated soil was reported at 37.6 mg/l and a cadmium concentration of 19.3 mg/l. This report indicated that at a ratio of waste to dry cement of .8, or a waste loading of 28% (on a stabilized product basis with 36% moisture content), that the stabilized product met the TCLP RCRA limits in place at the time (0.5mg/l lead, and 1mg/l cadmium). For more information on this study, see Haefner (1993).

An INEL RCRA Treatability Study was performed in 1994 on heavy metal contaminated soil. The untreated soil had a TCLP of 2.02 mg/l for cadmium and a TCLP of 41.4 mg/l for lead. This report indicated that at a ratio of waste to dry cement of 1, or a waste loading of 39% (on a stabilized product basis with 33% moisture content), that the stabilized product produced a TCLP of ≤ 0.066 mg/l for lead and ≤ 0.002 mg/l cadmium. For more information on this study, see Rybicki et al. (1994).

i. Normandy Park Apartment, Personal Communications with: EPA Contact Bill Denman (404-562-8939), Gulf Coast Recycling contact Joyce Morales-Carmella (813-626-6151).

j. Cedar Town Industries, Personal Communications with: The EPA contact is Annie Godfrey (404-562-8919) and the site remediation contractor was GNB Environmental Services.

2.1.3 EPA SITE Demonstration Projects

SITE Program Demonstration Projects have been completed in an effort by EPA to advance the science of soil stabilization. Completed demonstrations on stabilization of metal contaminated soils are listed below; see EPA (1997):

- Advanced Remediation Mixing, Inc., Completed demonstration of stabilization on metals contaminated soil, SITE Program Demonstration Project
- Funderburk & Associates, Completed demonstration of stabilization on metals contaminated soil, SITE Program Demonstration Project
- Solidtech, Inc., Completed demonstration of stabilization on metals contaminated soil, SITE Program Demonstration Project
- STC Omega, Inc., Completed demonstration of stabilization on metals contaminated soil, SITE Program Demonstration Project
- WASTECH Inc., Completed demonstration of stabilization on metals contaminated soil, SITE Program Demonstration Project.

2.1.4 Commercial and Government Soil Stabilization Facilities

2.1.4.1 Chemical Waste Management. INEEL employees conducted a site visit to Chemical Waste Management in Arlington, Oregon to tour facility operations and gain an understanding of equipment and processes used in stabilizing RCRA metal contaminated soil. This facility does not process radioactively contaminated materials, but routinely processes RCRA metal contaminated soils, primarily contaminated with lead and chromium. Average annual stabilization production is 25,000–30,000 tons per year of waste material. At this site, 50-yd³ batches of material are processed in lined pits using an excavator to mix the batch. Tacoma Seam flyash and Type C flyash are the primary stabilization agents used at this time; however, Portland cements have been used in the past. The selection of stabilization agents is primarily based on economics.^k

2.1.4.2 DOE Site, Hanford, Washington. INEEL employees conducted a site visit to the DOE Hanford site in Hanford, Washington, to tour facility operations and gain an understanding of equipment and processes used in stabilizing radioactively contaminated soils containing RCRA metals. The equipment observed in this visit does not operate on a continuous basis but has processed as much as forty 13-yd³ containers in 2 weeks production time. At this site, batches of material were processed in a lined concrete box using an excavator to mix the batch. Portland cement stabilization ingredients were used as the primary stabilization agents.^k

2.1.4.3 EnviroSAFE. INEEL employees conducted a site visit to EnviroSAFE, Inc. to tour the facility and to gain an understanding of a commercial soil processing operation. This facility processes soils contaminated with heavy metals.

k. Site visits to other treatment sites, personal communications with Brian Raivo, an INEEL mechanical engineer. Personal contact at Chemical Waste Management is Gary Fisher (541-454-3234). Personal contact at Hanford is Mike Casbon (509-372-9218).

2.2 Technology Selection

This section discusses the selection of Portland cement-based systems for stabilizing the SSSTF waste soils. Portland cement systems were selected because of their demonstrated ability to bind heavy metals and their readily available sources. The trade study results also suggest that Portland cement systems are commonly used in similar remediation activities.

The primary contaminants of concern are cadmium, chromium, lead, mercury, and silver. Of these metal species, chromium, lead and mercury are observed in the highest concentrations. Based on EPA guidance documentation (EPA 1997), cadmium and lead are the most amenable to cement-based stabilization, mercury is less amenable to stabilization in cement, and silver is not particularly amenable to cement-based stabilization. One valence state of chromium, Cr VI, is not amenable to cement-based stabilization, but if it can be reduced to Cr III it can be stabilized. The same EPA reference states:

“Wastes containing more than one metal are not addressed here, other than to say that cement-based solidification/stabilization of multiple metal wastes will be particularly difficult if a set of treatment and disposal conditions cannot be found that simultaneously produces low mobility species for all the metals of concern. For example, the relatively high pH conditions that favor Pb immobilization would tend to increase the mobility of As. On the other hand, the various metal species in a multiple metal waste interact (e.g., formation of low solubility compounds by combination of Pb and arsenate) to produce a low mobility compound.”

While not certain, it appears that cement-based stabilization is the most viable candidate for stabilizing INEEL waste. It is acknowledged that amendments and/or pretreatment of waste may be required to fully stabilize the INEEL waste. Cement was selected as a starting point for a number of reasons:

- Well known and established technology
- Formula can be adjusted to address a wide variety of contaminants
- Waste does not need to be dried, excess water can be solidified with the sediments
- Alkalinity retains metals and radionuclides
- Low materials cost
- Minimal equipment requirements
- Readily available
- Potential long-term impacts are better known than other binders
- Energy requirements are minimal.

The actual formulation of the stabilization mix, including any additives, will need to be based on further characterization results of the waste. The concentrations and inventory of heavy metals are likely overstated in the waste inventory because “worst-case” values are used to determine if a waste stream potentially required treatment.

Other stabilization agents were not selected for a variety of reasons at this time; however, these agents may be included as amendments to the basic cement formulation as needed. Lime-based binders are in common use and adequately stabilize metals, but do not have the same strength and durability. Phosphate-based products are known to enhance lead stabilization, but generally sacrifice physical properties such as compressive strength. Bitumen might fail in the presence of water, but could be an additional source of contaminants in itself and is energy intensive. Other amendments that may be considered for inclusion in the cement based mix include blast furnace slag, flyash, plasticizers, chloride, or sodium sulfide because of various reported instances in which they have enhanced the performance of the stabilization process.

TEST OBJECTIVES

This study will use surrogate waste material prepared by using representative site soils spiked with a known quantity of heavy metals. The surrogate will be subjected to an extensive matrix of tests wherein the Portland cement will be supplemented with chemical additives and the stabilization formulation (water and waste loading) adjusted. The objective is to establish a baseline treatment recipe that binds all the heavy metals in a nonleachable product.

The current criteria for disposal requires that the treated waste meet the ICDF WAC, which will include the following criteria:

- Meets Land Disposal Restrictions for hazardous wastes as defined in 40 CFR 268
- Exhibits no free liquid as determined by the paint filter test

Portland cement will be used as the primary binding agent for treating the waste. Admixtures, including flyash, blast furnace slag, or free sulfide, will only be used as necessary to meet criteria listed above.

Secondary objectives of this study relate to implementing this treatment on a large scale. It is desirable for the end product to remain in a nonslab form suitable for direct exhumation from the treatment site. The concept being that treated waste will be moved from the treatment facility and placed directly in a landfill. A friable solid material would allow simple materials handling for personnel and minimize subsidence in the landfill.